Performance Analysis of AIML-Based MPPT-Assisted Solar PV System under Different System Conditions

SYNOPSIS

Submitted by

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Introduction:

The aim of this study is to investigate the performance of an AIML-based MPPT algorithm in a solar PV system under varying operating conditions. The MPPT algorithm is designed to track the maximum power point (MPP) of the solar panel, which is affected by changing environmental conditions such as temperature, irradiance, shading, and load variations.[2]

Literature Review:

The use of solar energy has gained significant attention in recent years due to its environmental and economic benefits. One of the most important components of a solar PV system is the Maximum Power Point Tracking (MPPT) algorithm. MPPT is used to extract the maximum power from the solar panel by continuously tracking the Maximum Power Point (MPP). MPP is affected by various environmental factors such as temperature, irradiance, shading, and load variations.

Traditional MPPT algorithms such as Perturb and Observe (P&O) and Incremental Conductance (INC) have been widely used in the industry [8-10]. However, these algorithms have limitations in terms of their tracking accuracy, response time, and efficiency. To overcome these limitations, researchers have developed and tested various AI and ML-based MPPT algorithms.[1]

In recent years, there has been an increasing interest in developing AIML-based MPPT algorithms for solar PV systems [3]. AIML-based algorithms can learn and adapt to changing environmental conditions,

resulting in improved tracking accuracy, faster response time, and higher efficiency [11]. Various studies have investigated the performance of AIML-based MPPT algorithms under different operating conditions.[4-7]

In some studies, fuzzy logic-based MPPT algorithm was developed and tested under varying solar irradiance and temperature conditions. The algorithm demonstrated improved tracking accuracy and efficiency compared to conventional techniques[17-23]. Similarly, in another study, a neural network based MPPT algorithm was developed and tested under partial shading conditions. The algorithm demonstrated improved tracking accuracy and response time compared to conventional techniques.[14-16]

Furthermore, in a study, an adaptive neuro-fuzzy inference system (ANFIS)-based MPPT algorithm was developed and tested under different load conditions.[7] The algorithm demonstrated improved tracking accuracy and efficiency compared to conventional techniques.

Overall, the literature suggests that AIML-based MPPT algorithms can improve the performance of solar PV systems under different operating conditions. These algorithms can learn and adapt to changing environmental conditions, resulting in improved tracking accuracy, response time, and efficiency [12,13]. The proposed study aims to investigate the performance of AIML-based MPPT algorithm under varying operating conditions and compare it with conventional MPPT techniques. The results of this study will contribute to the development of more efficient and reliable solar PV systems.

Gaps/Motivation:

1. **Lack of comprehensive studies:** Although some studies have investigated the performance of AIML-based MPPT algorithms in solar PV systems, there is still a lack of comprehensive studies that evaluate the algorithm's performance under varying operating conditions. Such studies are necessary to determine the efficacy of AIML-based MPPT algorithms in real-world applications.
2. **Limited studies on comparative analysis:** There is a need for a comparative analysis of AIML-based MPPT algorithms and conventional MPPT techniques under varying operating conditions. Such a study can provide a better understanding of the advantages and disadvantages of these algorithms and their suitability for different applications.
3. **Lack of studies on response time:** Most of the studies on AIML-based MPPT algorithms have focused on their tracking accuracy and efficiency. However, response time is an equally important parameter, particularly in fast-changing environmental conditions. More studies are needed to evaluate the response time of AIML-based MPPT algorithms.
4. **Need for improved efficiency:** The efficiency of solar PV systems is a critical factor that affects their economic viability. AIML-based MPPT algorithms have the potential to improve the efficiency of solar PV systems. However, there is a need for more studies to evaluate their efficiency under different operating conditions.

5. **Importance of maximizing energy yield:** Maximizing the energy yield of solar PV systems is crucial for their widespread adoption. AIML-based MPPT algorithms have the potential to increase the energy yield of solar PV systems. However, there is a need for more studies to evaluate their performance in this regard.

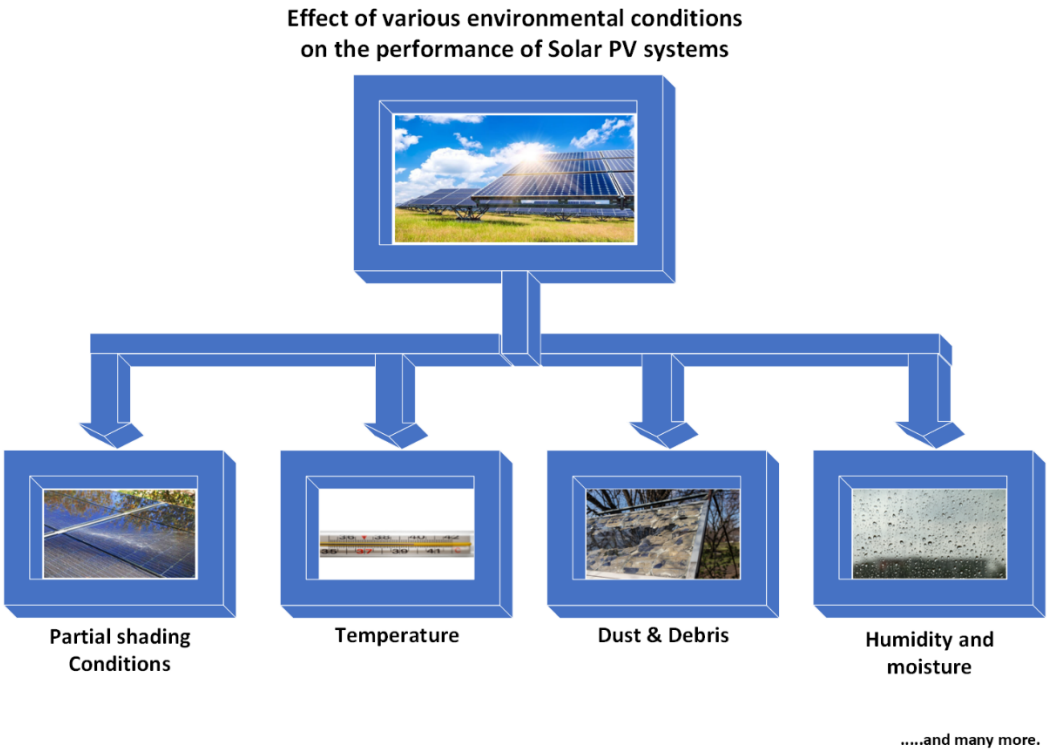

Fig. 1 – Various Environmental Conditions affecting the solar PV's.

In summary, the research on "Performance analysis of AIML-based MPPT-assisted solar PV system under different operating conditions" is motivated by the need to fill the gaps in the existing literature and improve the understanding of AIML-based MPPT algorithms' performance in solar PV systems. The proposed study aims to contribute to the development of more efficient and reliable solar PV systems that can deliver higher energy yields in real-world applications.

Objectives:

The objectives of the research on "Performance analysis of AIML-based MPPT-assisted solar PV system under different operating conditions" can be summarized as follows:

1. **Develop an AIML-based MPPT algorithm:** The research aims to develop an AIML-based MPPT algorithm that can learn and adapt to varying environmental conditions, resulting in improved tracking accuracy, response time, and efficiency.
2. **Analyze the performance of AIML-based MPPT algorithm:** The research aims to evaluate the performance of the developed AIML-based MPPT algorithm under different operating conditions, such as varying solar irradiance, temperature, shading, and load variations. The analysis will include the algorithm's tracking accuracy, response time, and efficiency compared to conventional MPPT techniques.
3. **Conduct a comparative analysis:** The research aims to conduct a comparative analysis of the developed AIML-based MPPT algorithm and conventional MPPT techniques under different operating conditions. The comparative analysis will provide a better understanding of the advantages and disadvantages of these algorithms and their suitability for different applications.
4. **Evaluate the response time:** The research aims to evaluate the response time of the developed AIML-based MPPT algorithm under fast-changing environmental conditions. The evaluation will provide insights into the algorithm's performance in real-world applications.

5. **Maximize energy yield:** The research aims to evaluate the developed AIML-based MPPT algorithm's performance in maximizing the energy yield of solar PV systems under different operating conditions. The evaluation will provide insights into the algorithm's potential for increasing the energy yield of solar PV systems.

In summary, the research aims to develop and evaluate an AIML-based MPPT algorithm's performance under different operating conditions, conduct a comparative analysis, and evaluate its potential to improve the efficiency and energy yield of solar PV systems. The research's findings will contribute to the development of more efficient and reliable solar PV systems that can deliver higher energy yields in real-world applications.

Methodology:

The research will be conducted by developing a simulation model of the solar PV system using MATLAB/Simulink software or we will develop a hardware to verify the results. The model will be validated by comparing the simulated results with the experimental data. The performance of the AIML-based MPPT algorithm will be compared with conventional MPPT techniques such as Perturb and Observe (P&O) and Incremental Conductance (INC) algorithms under varying operating conditions. The system's performance will be analyzed in terms of efficiency, power output, and response time.

Expected Results:

It is expected that the AIML-based MPPT algorithm will outperform the conventional techniques in terms of efficiency, power output, and

response time under different operating conditions. The algorithm's ability to learn and adapt to changing environmental conditions will result in improved MPP tracking accuracy, which will maximize the system's energy yield.

Conclusion:

This study will provide a comprehensive analysis of the performance of AIML-based MPPT-assisted solar PV systems under different operating conditions. The results will help in the development of more efficient and reliable solar PV systems that can deliver higher energy yields in real-world applications.

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